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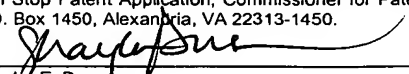
METHODS AND SYSTEMS FOR DISTRIBUTING APPLICATION DATA
AMONG MULTIPLE PROCESSING MODULES IN A TELECOMMUNICATIONS
NETWORK ELEMENT HAVING A DISTRIBUTED INTERNAL PROCESSING
ARCHITECTURE

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Description

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5 ARCHITECTURE

Technical Field

The present invention relates to methods and systems for distributing a
database among multiple processing modules. More particularly, the present
10 invention relates to methods and systems for distributing a database associated
with a telecommunications service among processing modules in a network
element having a distributed internal processing architecture.

Background Art

15 Some telecommunications network elements have distributed internal
processing architectures. For example, the Eagle[®] signal transfer point (STP)
and IP⁷ Secure Gateway[™] products available from Tekelec of Calabasas,
California, are two examples of such distributed processing systems. Figure 1 is
block diagram, which illustrates the distributed system architecture of a Tekelec
20 Eagle[®] STP 100. In Figure 1, STP 100 includes an interprocessor message
transport (IMT) communication bus 102, multiple signaling system 7 (SS7) link
interface communication modules (LIMs) 104, and multiple uniformly provisioned,

database service modules (DSMs) **106**. In this example, DSMs **106** are provisioned to support local number portability (LNP) processing of received signaling messages. Each of the DSMs of cluster **106** is provisioned with the same LNP translation data. Received signaling messages that require LNP translation processing are load-shared among DSMs of cluster **106**. As indicated in Figure 1, each DSM of cluster **106** contains a complete copy of all LNP translation data, which is obtained from a local provisioning system that includes a local service management system (LSMS) **110** and one or more Eagle® LNP application processor (ELAP) provisioning servers **112**.

In the exemplary STP architecture shown in Figure 1, a signaling message requiring LNP translation service is received by a LIM and is distributed to an available LNP DSM of cluster **106**. Such a system architecture is attractive because a minimal message processing burden is placed on the LIM communication modules, and consequently, high message throughput rates may be achieved. However, recent developments in the telecommunications industry have exposed a potential weakness or shortcoming in storing all of the LNP data in a single database. This shortcoming involves cost and processing inefficiencies that emerge when the amount of number portability data that must be stored and accessed on each DSM becomes great. For example, the time required to perform each lookup in the database increases as the size of the database increases. In addition, storing multiple copies of a large database unnecessarily wastes memory and card reload times will increase proportionally to the increase in database size.

Accordingly, there exists a need for improved methods and systems for storing and accessing large message processing data sets in a signaling message routing node.

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Disclosure of Invention

Methods and systems for distributing and accessing large amounts of signaling message processing data in a signaling message processing node having a distributed internal processing architecture are disclosed. According to one exemplary method, a large amount of signaling message processing data, such as number portability translation data, is distributed across multiple processing modules. Such data may be segmented according to NPA-NXX ranges or geographic regions, and LNP data associated with different regions or segments may be stored on different processing modules within a signaling message routing node.

15 Once the data has been divided, a signaling message requiring number portability processing may be received at a signaling link interface module. The link interface module may first select the service type for the message and then select the processing module that stores the segment of data for processing the signaling message. The link interface module may then forward the signaling message to the selected processing module. Because the data for the selected service is divided among multiple processing modules, the time required to process each signaling message is reduced over conventional methods in which each processing module stores the entire set of processing data for a particular service.

Alternatively, the service type may be stored in the DSM card which may result in the message picking the wrong DSM card and result in a double hop. For example, all messages requiring LNP or other types of translations may first be routed to one of the DSM cards. Service selection may be performed on the
5 DSM card. Once service selection is performed, the card that stores the segment of data for the DSM card may be identified. The receiving DSM card may then route the message to the appropriate DSM card within the STP.

Accordingly, it is an object of the present invention to provide methods and systems for segmenting and distributing a large database across multiple
10 processing modules.

It is another object of the invention to provide methods and systems for directing a received signaling message to a processing module that contains the data necessary to process the message.

Some of the objects of the invention having been stated hereinabove, and
15 which are addressed in whole or in part by the present invention, other objects will become evident as the description proceeds when taken in connection with the accompanying drawings as best described hereinbelow.

Brief Description of the Drawings

20 Preferred embodiments of the invention will now be described with reference to the accompanying drawings of which:

Figure 1 is a block diagram illustrating a conventional LNP database implementation in a signal transfer point;

Figure 2 is a block diagram illustrating an exemplary architecture of a signaling gateway (SG) routing node suitable for use with embodiments of the present invention;

Figure 3 is a block diagram of a routing node that includes an LNP
5 database distributed across multiple processing modules according to an embodiment of the present invention;

Figure 4 is a block diagram of an SCCP signaling message;

Figure 5 is a block diagram of an alternate architecture for a signaling message routing node with a distributed internal number portability database
10 according to an embodiment of the present invention;

Figure 6 is a block diagram of a signaling message routing node in which service selection is performed on a DSM card according to an embodiment of the present invention; and

Figure 7 is a flow chart illustrating exemplary steps that may be performed
15 in processing messages using a signaling message processing database distributed across multiple processing modules according to an embodiment of the present invention.

Detailed Description of the Invention

20 Disclosed herein are several embodiments of the present invention, which may include an underlying hardware platform similar to that of a signal transfer point (STP) or an SS7-over-Internet protocol signaling gateway (SG). Figure 2 is a block diagram illustrating an exemplary SG node **200**, which employs a highly

distributed, multi-processor system architecture suitable for use with embodiments of the present invention. As shown in Figure 2, SG **200** includes the following subsystems: a maintenance and administration subsystem (MAS) **202**, a communication subsystem **204** and an application subsystem **206**. MAS

5 **202** provides maintenance communications, initial program loading, peripheral services, alarm processing and system disks. Communication subsystem **204** includes an interprocessor message transport (IMT) bus that is the main communication bus or network in SG **200**. The IMT bus facilitates communication among the various modules and subsystems in SG **200**. The

10 IMT bus may include two 1 Gbps counter-rotating serial rings.

Application subsystem **206** includes processing modules or printed circuit boards capable of communicating with the other cards through IMT bus. Numerous types of processing modules can be included in SG **200**. Exemplary processing modules that may be part of application subsystem **206** include an

15 SS7 LIM **208** that provides SS7 links and X.25 links, a data communication module (DCM) **210** that provides an Internet protocol (IP) signaling interface to external nodes, and a high-speed asynchronous transfer mode (ATM) communication link module (HSL) **212**. A DSM **214** may host one or more signaling message processing applications, such as global title translation,

20 flexible routing, number portability translation, call screening, pre-paid calling service, mobile services (e.g., home location register, short message service center, mobile authentication center, equipment identity register, location-based

service), 800 number service, caller identification service, and other applications that involve routing or application layer signaling message processing.

From a hardware perspective, each processing module may include an application processor and a communications processor. The application
5 processor may perform telecommunications signaling message processing functions, such as parsing messages and performing database lookups. The communications processor on each module may control communications with other processing modules via the IMT bus.

According to one embodiment of the present invention, multiple DSMs
10 may be simultaneously deployed within an SG routing node, where each DSM module contains a different, smaller portion or segment of a larger database associated with a particular message processing service. One or more segmentation parameters may be used to determine how to segment a large database. For example, translation data associated a large national LNP
15 database may be divided into multiple, smaller LNP database segments, and each database segment may be loaded onto a different DSM processing module. A subscriber address (e.g., an SCCP called party address, a mobile subscriber identifier, etc.) may be used as a segmentation parameter, such that each smaller database segment contains LNP translation data associated with a
20 different subscriber NPA-NXX range.

Figure 3 illustrates an SG routing node **300** having a distributed database system of the present invention. In Figure 3, SG routing node **300** includes a high speed IMT communications bus **302** and a pair of MASP processor modules

304. MASP pair **304** implement the maintenance and administration subsystem functions described above. A number of distributed processing modules or cards may be coupled to IMT bus **302**. In Figure 3, these processing modules or cards include an IP-capable DCM **306**, an ATM-capable HSL **308**, and a pair of SS7 LIMs **310** and **312**. Each LIM may be connected to many other signaling points in a network via one or more individual signaling links, where an SS7 signaling link is typically a 56 kbps or 64 kbps DS0 link. Multiple signaling links connected to a common destination may be grouped into a virtual entity known as an SS7 signaling linkset. An IP socket connection is used in a manner that is analogous to a signaling link.

As illustrated in Figure 3, LIM **310** includes an SS7 MTP level 1 & 2 function **314**, an SS7 MTP level 3 message discrimination function **316**, a routing function **318** and a message distribution function **320**. MTP level 1 and 2 function **314** provides the facilities necessary to send and receive digital data over a particular physical medium, as well as to provide error detection, error correction and sequenced delivery of SS7 messages. Message discrimination function **316** receives signaling messages from the lower processing layers and applies a discrimination function that effectively determines whether an incoming SS7 message requires internal processing or is simply to be through switched. Examples of received SS7 messages that require internal processing include SCCP messages in need of global title translation (GTT), messages requiring number portability (NP) translation service, signaling network management

messages, and messages requiring other application services, as mentioned previously.

For received signaling messages that require MTP routing, routing function **318** is responsible for examining an incoming message received from discrimination function **316** and determining on which outbound linkset/link or signaling link equivalent (e.g., IP socket connection, etc.) the message is to be transmitted. Routing function **318** may also internally transmit the message to the outbound communication module (e.g., LIM, DCM, HSL) associated with the selected signaling linkset via IMT bus **302**.

If discrimination function **320** determines that a received signaling message requires processing by an internal application processor or subsystem of the SG node, then the message is passed to message distribution function **320**. In the embodiment illustrated in Figure 3, message distribution function **320** includes a service selection function **322**. Service selection function **322** directs the signaling message to an application processor module that is equipped to provide the appropriate message processing service. In the case where a message processing database has been segmented and distributed across multiple processor modules as illustrated in Figure 3, service selection function **322** may direct the signaling message to not only to a DSM that supports the correct service (e.g., LNP, GTT, etc.), but also to the specific DSM that contains the segment of data necessary to process the message.

In Figure 3, SG **300** includes a cluster of non-uniformly-provisioned DSMs that provide LNP translation service. These exemplary DSMs include DSM **324**,

which contains LNP translation data associated with subscribers in a first region, DSM **326**, which contains LNP translation data associated with subscribers in a second region, DSM **328**, which contains LNP translation data associated with subscribers in a third region, and DSM **330**, which contains LNP translation data associated with subscribers in a fourth region. A subscriber identifier, such as a wireline telephone number, mobile subscriber ISDN (MSISDN) number, or international mobile station identifier (IMSI) number, may be used as the basis for segmenting a large application database (e.g., a LNP database, a mobile number portability database, a global title translation database, etc.). SG **300** may also include a DSM **332** that provides GTT service. Service selection function **322** examine parameters associated with or contained within a received signaling message in order to determine which processing service is required (i.e., LNP or GTT) and subsequently direct the signaling message to the correct DSM within the application service cluster.

The present invention does not preclude load-sharing among multiple, uniformly provisioned, processors within the same database segment cluster. For example, multiple, identically provisioned, DSMs may be configured to support the LNP region 1 data segment. As such, once service selection function **320** has determined that a received signaling message requires processing by a DSM containing LNP region 1 data, the signaling message may be directed to the first available DSM that is provisioned with LNP region 1 data. Once message processing has been completed by the selected DSM, an appropriate outbound signaling linkset or socket connection is selected by the

DSM, and the processed message is directed via IMT bus **302** to a communication module (e.g., LIM, DCM, HSL) associated with the selected outbound linkset or socket connection for subsequent transmission to or towards a final network destination.

5

Service Selection

Service selection may be triggered after a received message passes standard message processing steps. For example, discrimination function **316** may examine a received signaling message and determine the message was received from an allowed originating node in the network. Discrimination function **316** may further examine a destination point code (DPC) parameter and a service indicator (SI) parameter in the received message and determine that the message has been assigned an SI value of 3, which indicates that the message is an SCCP message. Since SCCP messages addressed to routing node **300** require further internal processing, discrimination function **316** may pass the message to distribution function **320**. Distribution function **320** may receive such messages from discrimination function **316** and pass such messages to or invoke service selection function **322**.

Service selection function **322** first identifies the service type. In order to determine the service type, service selection function **322** may decode one or more message parameters. For example, service selection function **322** may decode and utilize network domain information (e.g., ANSI, ITU-International, ITU-National, etc.), a translation type (TT) indicator, a global title indicator (GTI),

a mobile application part (MAP) message type operation (Op) code, a numbering plan (NP) indicator, nature of address indicator (NAI), and SCCP subsystem (SSN) indicator. Service selection function **322** may use another parameter, such as the called party address to identify the DSM containing the segment of data for processing the message within the selected service type. For ISUP IAM messages directed to former end offices of ported out subscribers, service selection function **322** may use the called party dialed digits to send the message to the processing module containing the number portability translation data so that the IAM message can be re-directed to the called party end office to which the subscriber has been ported.

Figure 4 is a block diagram illustrating an exemplary SS7 SCCP signaling message illustrating some of the parameters that may be used by service selection function **322**. In Figure 4, SCCP message **400** includes a mobile application part (MAP) application layer payload. SCCP message **400** also includes an SS7 message transfer part (MTP) routing label **402**, that includes an SS7 origination point code (OPC) **404**, an SS7 destination point code (DPC) **406**, and a service indicator (SI) **408**. Message **400** further includes an SS7 SCCP component **410**, which includes called party information **412**. SCCP called party information may include a GTI parameter **414**, a TT parameter **416**, an SSN parameter **418**, a routing indicator (RI) **420**, an NP parameter **422**, an NAI parameter **424**, and called party address (CdPA) information **426**. A transaction capabilities application part (TCAP) layer **428** may also be carried in SCCP message **400**. The TCAP layer may include an op code parameter that identifies

the message type. Additional TCAP layer parameters, including mobile subscriber identifiers, such as mobile subscriber ISDN (MSISDN) and international mobile station identifier (IMSI) parameters may also be used by service selection function **322** to select a DSM for processing a received
5 signaling message.

Service selection may be based on any or all of the above mentioned signaling message parameters. For instance, in one embodiment of the present invention, a MAP Update Location message (Op code = 2) associated with a mobile subscriber having an MSISDN of 9193457017 that is received by the SG
10 **300** may be directed by service selection function **322** to one of many DSMs that are provisioned to support a flexible HLR routing address translation application, such as the Tekelec G-Flex[®] application. In such an example, the selected DSM may be one of a plurality of non-uniformly-provisioned flexible HLR routing address translation processors, which contains the range or segment of
15 translation data that includes the MSISDN value 9193457017.

While the description above focuses primarily on the processing of SS7 SCCP signaling messages, the present invention is not limited to processing SS7 messages. For example, the present invention may include processing IP-encapsulated SS7 messages, such as Internet Engineering Task Force (IETF)
20 SIGTRAN SCCP user adaptation (SUA) protocol messages. Such SUA messages may be received and processed via a DCM (e.g., DCM **306**) in a manner similar to that described above with respect to LIM **310**. In the case of SUA messages, service selection parameters similar or analogous to those

described above may be used to effect service selection according to the present invention. Session initiation protocol (SIP) messages may also be processed by a distributed database system of the present invention in a similar manner. For example, a subscriber identifier contained in a "To" field of a SIP message may
5 be used by a service selection of the present invention. Other parameters contained in a SIP message may be used in an analogous manner to those SS7 MTP, SCCP, TCAP, and MAP parameters described above during service selection processing.

Tables 1 and 2 below illustrate exemplary data structures associated with
10 one embodiment of a service selection algorithm of the present invention. Table 1 illustrates an exemplary service selector lookup data structure, which includes a complex service selector key including network domain, GTI, TT, NP, NAI, and SSN information. Although a multi-parameter, complex selector key is illustrated in Table 1, a service selection algorithm of the present invention may include a
15 simple lookup key that includes only a single parameter, such as TT. However, TT may be omitted as a service selection parameter without departing from the scope of the invention. In Table 1, each unique selector key value may be associated with service identifier, such as a GTT service identifier, an LNP service identifier, a mobile number portability service identifier, a CNAM service
20 identifier, etc.

<u>Domain</u>	<u>GTI</u>	<u>TT</u>	<u>NP</u>	<u>NAI</u>	<u>SSN</u>	Service
ANSI	2	11			23	LNP
ITU	4	3	3	2	6	HLR
ITU	4	4	3	2	14	GTT
ANSI	2	5			21	CNAM

Table 1: Service Selection Data

Once service selection has been performed using the information in Table 1, service segmentation information is next examined to identify the processing module that contains the segment of data associated with the selected service for processing the received message. Table 2 shown below maps each service identifier from Table 1, along with a subscriber identifier (or range of subscriber identifiers), to a particular DSM in the SG system. In Table 2, the DSM/application identifier may be a logical identifier, a physical location identifier, such as an internal communication bus address (e.g., card slot address), an external network address identifier (e.g., SS7 network address), an Internet protocol (IP) address (e.g., local or wide area network address), a data structure pointer, or a memory address. In the sample data presented in Table 2, the DSM identifier is an IMT communication bus card slot address. Also, the sample subscriber identifier data presented in Table 2 is stored in an NPA-NXX format or could point to a regional identifier (Northeast, Southeast etc.), which in turn would point to an NPA-NXX. In practice, any number of subscriber identifying digits may be used, and the subscriber identifier data need not be stored in range

format. Subscriber identifier data may be stored as individual subscriber identifiers.

<u>Service Type</u>	<u>Subscriber ID Range</u>	<u>DSM Identifier</u>
LNP	000000 - 250000	2201
LNP	250001 - 500000	2202
LNP	500001 - 750000	2203
LNP	750001 - 999999	2204
GTT	000000 - 500000	2205
GTT	500001 - 999999	2206

Table 2: Service Segmentation Data

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Referring again to the sample signaling message presented in Figure 4, service selection function **322** may decode and examine a number of parameters contained in message **400**, including: network domain = ANSI, GTI = 2, TT = 11, and SSN = 23. A lookup is performed using the data in Table 1, which returns a
10 match at the first entry in the table. The matching entry indicates that the required/requested service is LNP translation service. Table 2 is next accessed using the selected service identifier (i.e., LNP) as well as information associated with or extracted from the message that corresponds to the segmentation key or parameter (i.e., the subscriber identifier in NPA-NXX format) that was used to
15 segment the LNP database. In this example, an SCCP CdPA subscriber identifier (4354605500) is decoded from the message and used in the DSM

selection operation via a lookup in Table 2. The SCCP CdPA subscriber identifier contained in the message may be used as an LNP database segment indicator. Service selection function **322** may use this indicator, once the proper service has been selected, to identify the specific LNP DSM that contains the
5 translation data segment required to process the message.

The ranges of subscriber identifiers in Table 2 may be searched using the first 6 digits (NPA-NXX format) of the subscriber identifier (i.e., 435460) contained in a received message. In this example, a match is located at the second entry in Table 2, indicating that the LNP DSM at IMT bus address 2202 is
10 configured to process the message. In SG **300** shown in Figure 3, LNP DSM **326** is assigned an IMT bus address of 2202. Consequently, distribution function **320** directs the message to DSM **326** for LNP processing.

Service Selection Module

15 The present invention is not limited to locating the service selection function on a link interface module. Figure 5 illustrates another embodiment of an SG node **500** of the present invention, which utilizes a service selection module (SSM) **502** for receiving a message from a link interface module and directing the message to the appropriate one of many non-uniformly-provisioned
20 DSMs associated with a message processing service. SSM **502** includes a service selection function **322** as described above with respect to Figure 3. SSM module **502** also includes a message distribution function **320** for directing a message via IMT bus **302** to a DSM processor module. As will be described

below with regard to Figure 6, the service selection function may alternatively be incorporated directly on the DSM to avoid any potential bottlenecks in throughput.

5 In the implementation illustrated in Figure 5, LIM 310 may receive a signaling message, such as SCCP message 400 from Figure 4, and determine that the message may require processing by an application associated with SG 500. For example, such a determination may be made at LIM 310 when a message has an SI parameter value of 3 and is addressed to the point code of routing node 500. In such a case, LIM 310 may distribute the signaling message
10 to SSM module 502. The message is received by SSM 502, and service selection function 322 may examine various parameters contained in the message and, using information similar to that presented in Table 1 above, determine that processing of the message by an LNP translation application is required.

15 In a manner similar to that described above with regard to Figure 3, the selected service identifier (e.g., LNP) is used to select the appropriate one of four LNP DSM processors (i.e., DSM 324, DSM 326, DSM 328, DSM 330), which contains the specific LNP translation data required to process the signaling message.

20 Referring again to the signaling message illustrated in Figure 4, service selection function 322 may decode and examine a number of parameters contained in message 400, including: network domain = ANSI, GTI = 2, TT = 11, and SSN = 23. A lookup is performed using the data in Table 1, which returns a

match at the first entry in the table. The matching entry indicates that the requested service is LNP translation service. Table 2 is next accessed, using the selected service identifier (i.e., the LNP service identifier) and an SCCP CdPA subscriber identifier (4354605500) decoded from the message. The subscriber range data in Table 2 is searched using the first 6 digits (NPA-NXX) of the subscriber identifier (i.e., 435460). A match is located at the second entry in Table 2, indicating that the LNP DSM application processor at IMT bus address 2202 is configured to process the message. In SG **500**, shown in Figure 5, LNP DSM module **326** is assigned an IMT bus address of 2202. Consequently, distribution function **506** directs the message to DSM **326** for LNP processing.

Figure 6 is a block diagram of a signaling gateway **600** in which service selection function **322** is located on one of the DSM cards according to an embodiment of the present invention. Such an embodiment may be useful in situations where throughput on the LIMs is of concern. Referring to Figure 6, service selection function **322** is located on DSM card **324**, which contains the LNP data for region 1. Service selection function **322** may function as described above to select the service type (if services other than LNP are provided) and to select the DSM that contains the segment of data within the selected service type.

In operation, the LIMs in signaling gateway **600** may initially direct all SCCP messages that are addressed to the point code of signaling gateway **600** to DSM **324**, which contains LNP data for region 1. Service selection function **322** on DSM **324** determines whether the LNP translation can be performed

using region 1 LNP data. If the translation cannot be performed using LNP region 1 data, service selection function **322** identifies the DSM containing the appropriate LNP data, and distribution function on DSM **324** distributes the message to the identified DSM. Thus, in the embodiment illustrated in Figure 6,
5 two hops may be required to reach the appropriate segment of the LNP database. However, the processing burden on the LIMs is reduced. Moreover, unlike the embodiment illustrated in Figure 5, additional hardware is not required when the service selection function is placed on one of the DSM cards.

Figure 7 is a flow chart summarizing exemplary steps that may be
10 performed in segmenting a signaling message processing database and in processing messages using a segmented database according to an embodiment of the present invention. Referring to Figure 6, in step **700**, different segments of data from a message processing database are distributed among different processing modules. This step may be performed at provisioning time. In one
15 example, different segments of LNP data may be distributed among different database service modules in a signal transfer point, as discussed above.

After the database has been segmented, in step **702**, a signaling message is received. In step **704**, the service type is identified for the signaling message. Examples of service types include local number portability service, global title
20 translation service, calling name service, etc. Step **704** may be omitted when the only database service provided by the routing node is LNP.

In step **706**, a segment of data associated with the service type for processing the signaling message is identified. This step may include extracting

a parameter from the signaling message and identifying the corresponding segment of data. In step **708**, the message is forwarded to the processing module associated with the selected data segment.

By using a service selection algorithm of the present invention, received
5 messages that are identified as requiring LNP translation processing are not necessarily directed to the same LNP DSM application processor or arbitrarily load-shared among all LNP DSM processors in the SG system. Instead, a service selection algorithm of the present invention may additionally examine subscriber identifier information contained in a received signaling message and
10 use this information to determine to which of many non-uniformly-provisioned LNP DSMs the received message should be directed for LNP translation processing. Through the implementation of the present invention, signaling message processing applications, such as LNP, which involve very large amounts of translation data, may be broken up or segmented into many smaller,
15 more manageable databases. These non-uniform database segments may then be distributed over a plurality of processing modules within a processing system, such as an SG node, for increased processing efficiency.

It will be understood that various details of the invention may be changed without departing from the scope of the invention. Furthermore, the foregoing
20 description is for the purpose of illustration only, and not for the purpose of limitation--the invention being defined by the claims.